Lat 40.93845 Lon -123.63546

United States Department Of Agriculture
Forest Service
Shasta-Trinity National Forests
2400 Washington Avenue
Redding, CA 96001

Reply To: 3420 Date: January 28, 1993

Subject: Evaluation of Black Stain Root Disease in Douglas-fir Plantations and Douglas-fir Stands (Jake units), Orleans Ranger District, Six-Rivers National Forest (FPM Report No. N93-2)

To:Forest Supervisor, Six Rivers NF

On September 8, 9, and 10, 1992, Gregg DeNitto, Linda Haugen, and Dave Schultz of Forest Pest Management visited with district personnel on the Orleans Ranger District, Six Rivers National Forest, concerning a number of pest issues. A primary point of discussion was district concerns about black stain root disease (BSRD) in Douglas-fir. Also discussed were uses of prevention and supression funding. The district personnel involved were Sue MacMeeken, Mo Tebbe, and Tom Bouse. Bill Jones, Forest Silviculturist, and Dave Hubbard, Gasquet RD Culturist, also joined the discussions on September 10th.

Orleans Ranger District has two different biological situations where BSRD is of concern. One of these is young plantations, where the disease is creating holes and precommercial thinning may increase disease incidence. The other situation is in pole and sawtimber stands where management activities being considered include commercial thinning or partial harvest. These two situations, and corresponding actions suitable to the situations, are discussed separately on the following pages. Because biological characteristics of BSRD greatly impact management choices, a discussion of the known characteristics of the pathogen and its vectors is appended to this memo.

Black Stain Root Disease in Young Plantations

Orleans RD has large areas of young Douglas-fir plantations, some of which have been precommercially thinned, and some of which need to be thinned. District personnel have observed BSRD in many of these plantations, but information has not been collected on the level or rate of mortality, or on how many acres of plantations are affected. Observations on the behavior of the disease in the Pacific Northwest suggest that BSRD has the potential to cause major losses in growing stock. The potential for loss is influenced by a number of factors, including past harvest/disturbance regimes, thinning activities, and site characteristics.

District concerns were discussed during a series of visits to typical plantations, including the Perch Insect Salvage Unit D (near Jake) and several plantations in the Bluff Creek drainage. The major topics of concern can be grouped as follows.

A. Resource Impact Concerns. (How much damage is it causing?)

The district has a need to quantify the damage by BSRD. They would like to know which of their plantations are affected, and what proportion of the area is impacted. This type of information can be acquired through surveys. The nature of the plantations is such that an entirely ground-based survey would be difficult. (Many of the plantations occur on steep landscapes covered with debris and dense vegetation.) Past attempts at detecting and quantifying this disease on aerial photographs have had limited success. Other remote sensing techniques may be more productive.

In addition to knowledge about current losses, the district would like to be able to predict future losses. This requires a knowledge of what factors influence the incidence of disease and its increase.

B. Resource Management Concerns. (How can we manage to reduce or minimize losses?)

It is desireable to minimize losses by making proper management decisions. There is significant evidence that precommercial thinning can increase disease incidence. However, this does not occur on all sites or situations. It would be useful to know whether precommercial thinning will result in introduction of the disease or increases in losses on a given site. Having knowledge of what factors influence the occurrence and spread of BSRD would allow us to select appropriate management activities.

There is a need for FPM assistance in developing and implementing a survey to address resource impact concerns. A 2-stage survey system has been used elsewhere to determine answers to the questions of disease incidence and damage. An extensive roadside survey of most plantations, followed by an intensive survey of selected plantations can provide information on the incidence of BSRD on the District and the level of damage. We will work with District personnel to try to initiate survey efforts in 1993 and provide some funding. We may also examine the utility and effectiveness of newly acquired airborne videography to detect this disease in plantations.

A comprehensive survey would provide information on the current losses. Prediction of future losses and the effects of management activities is more difficult. A database of the current conditions combined with information on site characteristics and history may reveal patterns which will allow us to predict sites where losses can be expected. A risk-rating or expert system, however, will take significant investment of time, effort and research to develop. At this time, we do not have the information or capabilities to develop such a system. If the Forest believes this is a critical need, we will work with them to encourage PSW station to provide the necessary research.

Research and observations have provided some insight to address resource management concerns; however, many of the questions remain unanswered. We know that the pathogen can be introduced to uninfected areas through the activities of insect vectors, and we know something about the biology of the vectors. We may limit our thinning activities to times when the vectors are less active. We can minimize site disturbance and soil compaction at all stages of stand management. Unfortunately we do not have a risk rating system developed to indicate what level of caution is needed on specific sites to prevent unacceptable losses.

Black Stain Root Disease in Pole and Mature Stands

There is little information available on how BSRD functions in older stands. Although the greatest damage from the disease has been observed in young plantations, we know that the pathogen is capable of killing mature trees. Mortality in mature trees is most commonly associated with a past disturbance regime (such as tractor logging or thinning) or with stress events (such as road construction), however, the disease has also been observed killing trees in undisturbed stands. We know very little about the dynamics of the disease in mature stands over time. We do not know what effect activities such as commercial thinning or uneven-age management will have on disease activity. The proposed Jake Timber Sale represents an opportunity to learn more about the disease in older stands.

The proposed Jake Timber Sale consists of 5 thinning units, all of which are overstocked. All 5 units contain stands of primarily Douglas-fir resulting from natural regeneration following a fire 70 years ago. There was no prior disturbance (logging) in these stands. Generally, there was no sign of previous black stain observed in these stands, although it is known to occur in the surrounding stands. Recently black stain has been observed affecting vigorous dominant/codominant trees on the units.

The main objective for these units is timber management, and the intent is to maintain them as even-aged stands. The prescription is to thin from below. The units vary in slope, stocking level and size of the trees. A cable operation would be used to enter 2 of the units, a tractor operation for 2 of the units, and a combination for the 5th unit.

At the time of the site visit, the possibility of seeking funding for an administrative study in these stands was discussed. It appeared that a study would be beneficial, but that applying for administrative study funds might not be a feasible way to proceed. A monitoring effort, carried out by FPM and District personnel, could be the most effective way to collect information from these stands. When a decision is made to initiate the Jake Timber sale, FPM can assist in surveying the 5 units and identify the location of BSRD. Following the sale, these units can be monitored to track the activity of BSRD in the stands. If similar stands can be identified which are in the vicinity and are not scheduled for entry, these stands could be surveyed and monitored to serve as a comparison.

FPM-Redding will continue to work with the District in these endeavors. If you have other questions or need additional assistance, please contact me at (916) 246-5101.

/s/ Gregg DeNitto

GREGG A. DeNITTO
LINDA HAUGEN
Forest Pathologists
FPM Northern California Service Area

Biology of Black Stain Root Disease in Douglas-fir

Symptoms

Leptographium wageneri var. pseudotsugae (syn. Verticicladiella wageneri) is a native pathogen which causes black stain root disease (BSRD) on Douglas-fir throughout the Pacific Northwest. In younger age classes, the stand symptoms are typical of root diseases in this region, i.e. pockets of affected trees demonstrating more advanced symptoms or older mortality near the center of the pocket. The symptoms on individual trees may include declining crowns, shortened terminal growth, off-color foliage, stress cone crops and resinosis on the lower bole. Generally, infected trees die within 2 years of onset of crown symptoms. The presence of the disease is confirmed by a dark stain following the annual rings in the wood at the base of the stem or on the roots.

In older age classes, individual tree symptoms are similar, but death of individual trees may take 2 to 8 or more years. The effects of the disease may be evident on individual trees or small aggregations, making it difficult to identify distinct pockets. Mortality of black stain affected trees may mistakenly be attributed to other factors, such as wood borers.

Life cycle

There are at least three strains of the causal agent, L. wageneri, which are specific to certain host tree species. The strain on Douglas-fir is specific to this host and is not known to infect other tree species. The fungus occurs in the roots and lower boles of infected trees. It occupies the vascular tracheids in the sapwood, blocking water transport and leading to tree death. Hyphae are limited to the xylem tracheids and apparently are unable to colonize living parenchyma cells (Hessburg and Hansen 1987). Several root-inhabiting insect vectors are involved in dispersion of the fungus. These insects feed and breed in the phloem and cambium on roots of cut and declining Douglas-firs. The phloem-feeding insects colonize the roots over a period of 2 to 4 years during the decline of the tree and after tree death (Witcosky and Hansen 1985). L. wageneri sporulates inside insect galleries in infected roots and root collars (Goheen and Cobb 1978). Fruiting bodies of the fungus form on gallery walls, producing sticky droplets of spores which protrude into the gallery lumens (Hessburg et al. 1989). When the insects emerge from the infected tissue, some young adult beetles are contaminated with spores as they brush against the sticky droplets (Hessburg et al. 1989). The contaminated beetles fly or walk from the brood roots to other roots and burrow through the duff and soil to feed or breed, wounding the new roots of either standing trees or cut stumps. Wounds that expose sapwood xylem are required for infection since L. wageneri hyphae are unable to penetrate live bark and cambial tissues (Hessburg and Hansen 1987). Once established, the black stain fungus rapidly colonizes root and stem sapwood xylem. The roots of cut trees are susceptible to infection by the fungus for at least 7 months after the stem has been removed (Witcosky, Schowalter and Hansen 1986b).

Once an infection center is established, spread of the infection from tree to tree occurs through root grafts that join healthy and diseased trees, and between closely associated roots via limited growth of the pathogen through

soil (Hessburg and Hansen 1986a). Infection between trees that are not root grafted occurs through small roots via xylem exposed by the emergence of rootlets or other natural openings (Hansen et al. 1988). New infections that result from tree to tree spread are not related to tree vigor. Larger trees with extensive root systems may be more likely to become infected than small trees with limited root systems (Goheen and Hansen 1978).

Hansen and Goheen (1988) recorded that BSRD infection centers in 5- to 30-year-old Oregon plantations expanded radially at an average rate of 0.9 meters per year for the 1st five years of measurement and 0.4 meters per year for the next 5 years. Within a center, 31% of the trees were killed during the period of observation. It appears that mortality progresses less rapidly as trees age; however, the value of individual trees also increases. Hansen and Goheen (1988) also noted that the mortality rate within established root disease centers did not differ between thinned and unthinned stands. Thus the difference in losses from black stain in thinned vs unthinned stands may be due to the differences in number of infection centers initiated, rather than from rate of expansion of centers. Disease centers may continue to expand until there is a break in host roots, such as by the presence of a non-susceptible species, a road, or a stream.

Hessburg and Hansen (1986b) recorded a maximum growth rate of 3.6 meters per year for L. wageneri in Douglas-fir roots in the field. Thus the expansion rate of root disease centers can be accounted for by the growth rate of the fungus in tree roots. Soil temperature and moisture affect the growth of the fungus in soil and roots, so these factors may affect the rate at which an infection center expands. Hicks (1978) observed that growth of L. wageneri var ponderosae, the pine strain of the fungus, was favored by moist, but not saturated, soil conditions. Goheen et al. (1978) confirmed that moist soils were conducive to infection by the pine strain. Hessburg and Hansen (1986b) found that soil temperatures of 15-18°C led to fastest growth, and less than or equal to 18°C favored infection. Thus sites with cool, moist soils may be more favorable to growth of the pathogen. Information on other soil characteristics which might favor the fungus is very limited.

BSRD is a wilt disease, rather than a wood decay, and the fungus colonizes actively conducting xylem tracheids (Smith 1967), apparently receiving nutrition from the sap and cytoplasmic contents (Hessburg and Hansen 1987). The pathogen probably is not active in long-dead material; however, tree roots may remain "alive" for some time after the tree is apparently dead. Adams and Cobb (1986) found that the fungus remained viable in Douglas-fir stump roots and/or soil, and was able to infect seedlings, for at least 24 months after logging. There is one report of the pinyon pine isolate being recovered from the roots of a pinyon pine which had been dead for 10 years in Mesa Verde National Park (Wagener and Mielke 1961).

Vectors

Three phloem-feeding insects are frequently associated with the roots and lower stem of diseased Douglas-fir: the Douglas-fir root beetle, Hylastes nigrinus, and 2 weevils, Steremnius carinatus and Pissodes fasciatus (Witcosky and Hansen 1985). All three have been observed to feed on both diseased and healthy hosts and are capable of carrying inoculum and successfully transmitting the pathogen

to healthy plants (Witcosky, Schowalter, and Hansen 1986b). The 3 insects differ in their biology, and thus differ in their likelihood of vectoring the disease under a given set of conditions. H. nigrinus and S. carinatus appear to be the vectors involved in most situations. The fungus has also been isolated from the silver fir beetle, Pseudohylesinus grandis (Jackman and Hunt 1975).

Adult H. nigrinus are attracted to roots of cut and dead and declining Douglas-fir. The roots of trees killed by the Douglas-fir beetle (Dendroctonus pseudotsugae) are particularly attractive (Rudinsky and Zethner-Møller 1967), as are roots infected by BSRD (Witcosky, Schowalter and Hansen 1987). Within the perimeter of an area with stressed roots, both healthy and stressed roots may be attacked indiscriminately. Prior to mating, the adults feed on thin roots of older Douglas-fir which are dead or dying or have been recently felled. They may also feed on young Douglas-fir in plantations. After maturation feeding, adult beetles dig through the soil to reach susceptible roots, then breed in the roots. In western Oregon, invasion of roots and stumps begins in late May. Egg galleries are initiated in roots greater than 1 cm diameter in early to mid June. The larvae feed in the phloem through the summer and generally overwinter in the galleries as full-grown larvae or adults. Emergence in the spring and flight periodicity throughout the summer are greatly influenced by temperature; the beetles are relatively inactive when temperatures are below 61°F or above 75°F (Zethner-Møller and Rudinsky 1967).

Steremnius carinatus is a large, flightless, long-lived weevil. The length of its life cycle is variable, depending on temperature, but generally adults emerge in mid to late summer. The adults are omnivorous, and will feed on a variety of dead and living plant materials, including the phloem of young trees near soil line. Feeding damage in plantations can cause significant mortality, however they are more likely to feed on seedlings when other food is limited. The insect generally overwinters in the soil as adults, then breeds in the vicinity of their origin the following spring. Adults may survive over 2 years, breeding for 2 seasons. The eggs are laid in niches chewed under bark scales of roots and buried slash (Condrashoff 1968). There is evidence that S. carinatus is preferentially attracted to black stain diseased Douglas-fir roots (Witcosky, Schowalter and Hansen 1987). The larvae make irregular galleries in phloem, then pupate in chip cocoons (Condrashoff 1968).

Since S. carinatus is flightless and long-lived, its population dynamics differ from H. nigrinus. Although there is less potential for long-distance dispersal and rapid influx into a stand, the weevil can be a significant proportion of the root inhabiting insects on a site. There is evidence that S. carinatus occupies an earlier niche in the progression of insects in declining roots; i.e. it tends to colonize material in advance of other root feeding beetles (Witcosky and Hansen 1985). Although S. carinatus may not be as important as H. nigrinus in long-distance vectoring of the black stain fungus, it may be quite important over short distances and in localized spread (Hansen et al. 1988). In a study on 3 sites, Witcosky and Hansen (1985) found that populations of S. carinatus varied greatly between sites. Timing of thinning activities apparently has little effect on numbers of S. carinatus (Witcosky, Schowalter and Hansen 1986a).

Management Implications

There is no known method of directly controlling BSRD once it is established in a stand. However, management strategies that prevent introduction or intensification of BSRD in stands can reduce losses. These strategies include minimizing site disturbance, manipulating species composition, and restricting thinning activities.

Site disturbance produces conditions favorable for the vectors of BSRD, and may be a key factor in the introduction or intensification of the disease in a stand (Witcosky 1989). Disturbance activities include road construction and maintenance, thinning, and harvesting. BSRD is found more frequently in roadside strips than in areas away from roads, and trees which become infected along roads often have been physically wounded or had their roots compacted or covered by fill (Hansen 1978). New road construction through young Douglas-fir plantations should be avoided, especially in the vicinity of known BSRD centers (Hessburg et al. 1989). Brush cutting machinery used in road maintenance wounds trees and may increase vector activity along roads (Hessburg et al. 1989).

To minimize site disturbance during harvest or commercial thinning activities, a timber harvest system should be selected which causes the least soil compaction and soil profile disruption. High lead or skyline yarding are preferable to tractor yarding when an option exists. If tractor yarding is selected, the area covered by skid trails should be minimized and yarding should be restricted to the dry season, when the risk of serious soil compaction is reduced. Skid trails should be designated on the ground prior to the initiation of felling activities, and tree felling should be done to the yarding lead. Tractor yarding should not be used on soils which are prone to compaction by heavy equipment even when dry. (Hessburg et al. 1989).

Manipulation of species composition may reduce losses due to BSRD. When establishing new plantations near areas where BSRD is a known management concern, a mix of species should be planted to provide future options for species manipulation (Hessburg et al. 1989). When thinning in BSRD affected plantations, a high proportion of crop trees of species other than Douglas-fir should be selected if possible, particularly along old skid trails.

Increased incidence of BSRD in young Douglas-fir plantations has been observed in association with precommercial thinning (Harrington et al. 1983). The activity of insect vectors is increased by precommercial thinning (Witcosky et al. 1986a). Timing of thinning activities can be manipulated to minimize the attractiveness of thinned stands to vectors. Most of the insect vectors emerge and breed in spring and early summer; if thinning activities are conducted after the peak of insect activity but before autumn, the thinning slash will be dried and unattractive to the insects by the next spring (Witcosky et al. 1986a). A general guideline for thinning in Oregon is between late June and early September, however, the optimum thinning window will vary by location and weather.

References

Adams, D.H., and F.W. Cobb, Jr. 1986. Infection of outplanted Douglas-fir seedlings by Verticicladiella wageneriii (Blackstain Root Disease) when planted around infected Douglas-fir stumps. California Forestry Note No. 98, December 1986; 12 pp.

Condrashoff, S.F. 1968. Biology of Steremnius carinatus (Coleoptera: Curculionidae), a reforestation pest in coastal British Columbia. The Canadian Entomologist 100:386-394.

Goheen, D.J., and F.W. Cobb, Jr. 1978. Occurrence of Verticicladiella wageneriii and its perfect state Ceratocystis wageneri sp nov., in insect galleries. Phytopathology 68:1192-1195.

Goheen, D.J., F.W. Cobb, Jr., and G.N. McKibbin. 1978. Influence of soil moisture on infection of ponderosa pine by Verticicladiella wageneriii. Phytopathology 68:913-916.

Goheen, D.J., and E.M. Hansen. 1978. Black Stain Root Disease in Oregon and Washington. Plant Disease Reporter 62(12):1098-1102.

Hansen, E.M. 1978. Incidence of Verticicladiella wageneriii and Phellinus weirii in Douglas-fir adjacent to and away from roads in western Oregon. Plant Disease Reporter 62(2):179-181.

Hansen, E.M., and D.J. Goheen. 1988. Rate of increase of black-stain root disease in Douglas-fir plantations in Oregon and Washington. Can. J. of For. Research 18:942-946.

Hansen, E.M., D.J. Goheen, P.F. Hessburg, J.J. Witcosky, and T.D. Schowalter. 1988. Biology and Management of Black-Stain Root Disease in Douglas-fir. pp 63-80 IN: Leptographium Root Diseases on Conifers, ed by Harrington and Cobb. APS press, St. Paul, MN.

Harrington, T.C., C. Reinhart, D.A. Thornburgh, and F.W. Cobb, Jr. 1983. Association of Black-Stain Root Disease with Precommercial thinning of Douglas-fir. Forest Science 29(1):12-14.

Hessburg, P.F., D.J. Goheen, T.F. Gregg, and H. Koester. 1989. Survey of black stain root disease incidence and severity in 10- to 30-year-old Douglas-fir plantations on the Medford District, Bureau of Land Management. Region 6 FPM report R6-89-05 (USDA-Forest Service).

Hessburg, P.F., and E.M. Hansen. 1986a. Mechanism of intertree transmission of Ceratocystis wageneri in young Douglas-fir. Can. J. of For. Research 16:1250-1254.

Hessburg, P.F., and E.M. Hansen. 1986b. Soil temperature and rate of colonization of Ceratocystis wageneri in Douglas-fir. Phytopathology 76:627-631.

Hessburg, P.F., Sr., and E.M. Hansen. 1987. Pathological anatomy of black stain root disease of Douglas-fir. Can. J. of Botany 65:962-971.

Hicks, B.R. 1978. Growth of Verticicladiella wageneriì through soil and infection of Pinus ponderosa as related to selected soil properties. MS Thesis, University of California, Berkeley. 135 pp.

Jackman, R.E., and R. Hunt. 1975. Black stain root disease in Douglas-fir on Jackson State Forest. California Division of Forestry State Forest Notes No. 58, April 1975. 4 pp.

Rudinsky, J.A., and O. Zethner-Møller. 1967. Olfactory responses of Hylastes nigrinus (Coleopter:Scolytidae) to various host materials. The Canadian Entomologist 99:911-916.

Wagener, W.W., and J.L. Mielke. 1961. A staining-fungus root disease of Ponderosa, Jeffrey, and Pinyon pines. Plant Disease Reporter 45(111):831-835.

Witcosky, J.J. 1988. Root Beetles, stand disturbance, and management of black-stain root disease in plantations of Douglas-fir. Pp 58-70 IN: Insects Affecting Reforestation: Biology and Damage. Ed by Rene Alfaro and S. G. Glover. Proceedings of a mtg of the IUFRO working group on Insects affecting Reforestation (S2.07-03) held under the auspices of the XVIII International Congress of Entomology, Vancouver, B.C., Canada, July 3-9, 1988.

Witcosky, J.J., and E.M. Hansen. 1985. Root-colonizing insects recovered from Douglas-fir in various stages of decline due to Black-Stain Root Disease. Phytopathology 75:399-402.

Witcosky, J.J., T.D. Schowalter and E.M. Hansen. 1986a. The influence of time of precommercial thinning on the colonization of Douglas-fir by three species of root-colonizing insects. Canadian Journal of Forest Research. 16:745-749.

Witcosky, J.J., T.D. Schowalter and E.M. Hansen. 1986b. Hylastes nigrinus (Coleoptera:Scolytidae), Pissodes fasciatus and Steremnius carinatus (Coleoptera:Curculionidae) as vectors of black-stain root disease of Douglas-fir. Environmental Entomology 15:1090-1095.

Witcosky, J.J., T.D. Schowalter and E.M. Hansen. 1987. Host-derived attractants for the beetles Hylastes nigrinus (Coleoptera:Scolytidae) and Steremnius carinatus (Coleoptera: Curculionidae). Environmental Entomology 16(6): 1310-1313.

Zethner-Møller, O., and J.A. Rudinsky. 1967. On the biology of Hylastes nigrinus (Coleoptera:Scolytidae) in Western Oregon. The Canadian Entomologist 99(9):897-911.